Gas injection tests on a Sand Bentonite Mixture:
Investigation on the effect of pore water chemistry

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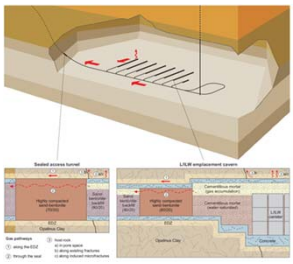
CONTEXT

Within the framework of the **FORGE** project the **impact of gas generation and migration** is studied to assess the **long term performance** of nuclear waste repositories



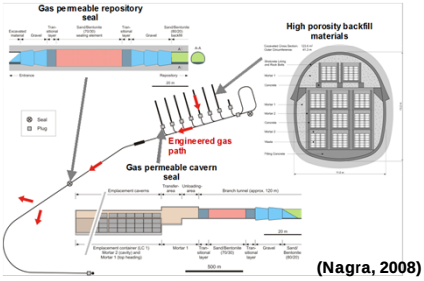
(Nagra, 2008)

The continuous generation **of gases from anaerobic corrosion of metal canister** containing the waste can cause the **excessive** increase of the **gas pressure in the cavern** causing fissuring of the host rock. In such conditions the **long term performance** of the repository are jeopardised (Nagra, 2008)

Solutions:

Engineered gas transport system (EGTS) to create a preferential gas flow path but preserving the retention capacity of the barriers

Sand/bentonite as backfilling material of seals and plugs for L/ILW repository: **high gas permeability + low hydraulic conductivity**



(Nagra, 2008)

AIMS OF THE STUDY

▶ To investigate the **influence of the pore water chemistry on swelling capacity and breakthrough pressure**

$$P_g(C) > P_{sw}(C) + P_w$$

Waters characteristic: Two type of water waters with different salt concentration

▶ **Distilled:** Is used to determine the maximum swelling capacity of smectite

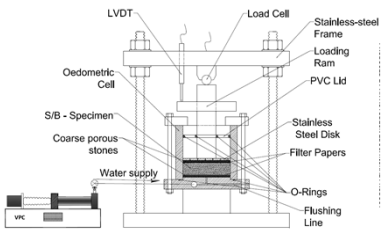
▶ **Synthetic:** Mainly contains Na^+ and CL^- (π = 0.9 kPa). It is used to reproduce the in situ condition of a real repository

SWELLING BEHAVIOUR OF THE S/B MIXTURE

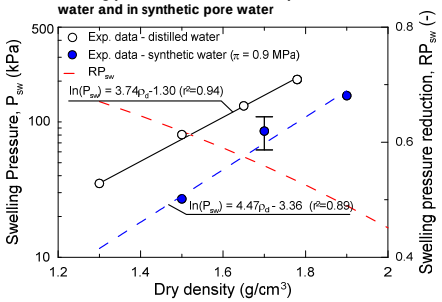
The presence of different **ions** is affecting the swelling capacity of the smectite minerals in the MX80 bentonite

Constrained swelling tests: executed on specimens of 80/20 S/B mixture compacted at dry densities and saturated with two type of water

Experimental setup



Swelling pressures of the S/B developed with distilled water and in synthetic pore water



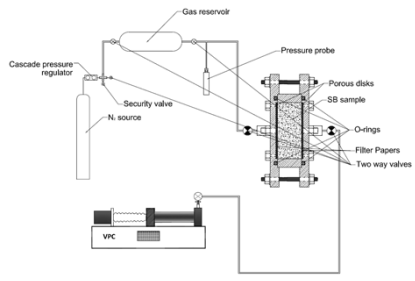
▶ **Exponential increment of the swelling pressure with the dry density**

▶ **Psw reduction in the range of 67% - 45% for the dry density in the range of 1.3 - 1.9 g/cm³ with synthetic water**

GAS BEAKTHROUGH PRESSURE

executed under isochoric / constant stress condition on fully saturated specimens of 80/20 S/B mixture compacted at ρ_d = 1.5 g/cm³

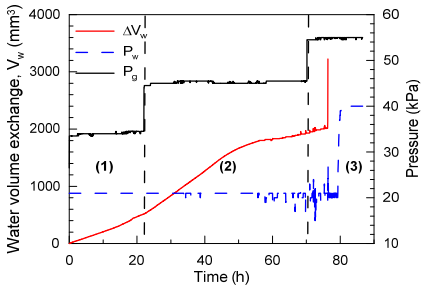
Experimental setup



▶ Can be connected to any different type of cell

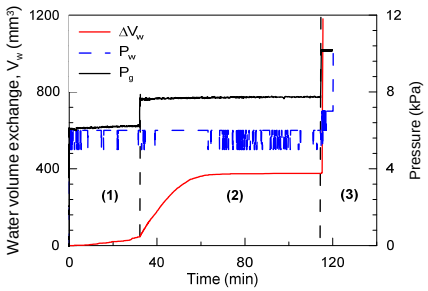
▶ Water pressure is maintained constant while gas pressure is increased in steps

Results in with distilled water



Phase n°	$P_{g,bot}$ (kPa)	$P_{w,top}$ (kPa)	q_n (m/s)
1	34	20	$3.25 \cdot 10^{-9}$
2	45	20	-
3	55	20 to 40	$\approx 4.99 \cdot 10^{-6}$

Results with synthetic water (π = 0.9 MPa)



Phase n°	$P_{g,bot}$ (kPa)	$P_{w,top}$ (kPa)	q_n (m/s)
1	6	5-6	$1.14 \cdot 10^{-8}$
2	7.7	5-6	-
3	10.2	6 to 10	$\approx 1.04 \cdot 10^{-5}$

▶ **Important reduction of the breakthrough pressure**

▶ **The normalized outflow increased of 1 order of magnitude with synthetic water**

CONCLUSIONS:

- The use of synthetic water produces an important reduction of the swelling pressure of the mixture
- The reduction of the swelling capacity of the mixture leads to the reduction of the breakthrough pressure
- An important increase of the measured outflow is detected when synthetic water is used in the gas experiments

PERSPECTIVE

- Further measurements are foreseen at different dry density
- Microstructural investigation will be performed on specimens fully saturated with the two waters

ACKNOWLEDGEMENT:

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REFERENCE:

Nagra (2008) Effects of post-disposal gas generation in a repository for low- and intermediate-level waste sited in the Opalinus Clay of Northern Switzerland. Nagra Technical Report 08-07, October 2008.